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THE IMPACT OF THE GLOBAL FINANCIAL CRISIS ON THE MARKET EFFICIENCY OF CAPITAL MARKETS OF SOUTH EAST EUROPE

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Abstract

The study uses the GARCH models to estimate market efficiency of eleven stock markets from South East Europe (SEE) - Bulgaria, , Croatia, Greece, Serbia, Slovenia, Turkey, Romania, Montenegro, Macedonia, Banja Luka and Sarajevo (Bosnia and Herzegovina) over the period from 2005 to 2015 with the accent on the effect of the global financial crisis of 2008 on the market efficiency.

The results reveal that eight of eleventh of analyzed markets can be defined as market inefficient according to the Efficient Market Hypothesis (EMH) during the whole studied period. From pre-crisis to crisis period five of the SEE indices worsen their market efficiency in the terms of the weak form of the EMH. The group of indices with relatively high market efficiency during the post-crisis period is the largest one in comparison with the previous periods. All things considered, it seems reasonable to assume that SEE markets aren't homogeneous and uniform in the contest of EMH.

Keywords: Efficient Market Hypothesis, financial crisis, efficiency and information asymmetry, capital markets.

JEL: C32, G01, G14, G15

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Introduction

The global financial crisis of 2008 can be defined as a start point of a period characterized by significant disturbances in the financial markets. Efficient market hypothesis and the random walk hypothesis have been major issues in finance for the past fifty years. The term efficiency is used to characterize a market in which relevant information is impounded into the price of financial assets. According to the efficient markets hypothesis (EMH) market prices fully reflect all available information. This hypothesis was developed independently by Paul A. Samuelson and Eugene F. Fama in the 1960s. Also, Fama defined three forms of the informational efficiency of the capital market: weak-form (future prices of the financial assets cannot be estimated using the past values), semi-strong form (current prices reflect all the public information available about the assets) and strong form (current prices reflect all public and non-public information about the assets).

We find evidence that the capital markets in, Bulgaria, Croatia, Greece, Serbia, Macedonia, Romania, Banja Luka and Sarajevo (Bosnia and Herzegovina) are defined as market inefficient according to the EMH during the whole period. From pre-crisis to crisis period the five SEE indices (Banja Luka, Sarajevo, Greece, Slovenia, and Turkey) worsen their market efficiency in the terms of the weak form of the EMH. The group of indices with relatively high market efficiency during the post-crisis period is the largest one in comparison with the previous periods.

In order to see the impact of the global financial crisis of 2008 on the market efficiency of the studied indices, the full data set (01.01.2004 – 04.11.2015) is divided into three sub-periods: pre-crisis, crisis and post-crisis. The indices under examination are eleven indices represent all capital markets of South East Europe: the Bulgarian SOFIX, the Banja Luka BIRS (Banja Luka stock exchange is in Bosnia and Herzegovina), the Sarajevo BIFX, the Greek Athex Composite Share Price Index, the Macedonian MBI10, the Romanian BET, the Serbian BELEX15, the Croatian CROBEX, the Slovenian SBI TOP, the Turkish BIST100 and the Montenegrin MONEX. We use daily returns to estimate the information efficiency in the case of EMH, applying the models of GARCH family models.

The paper is organized into five sections. The first section initiates with the introduction. Section 2 reviews the literature on the EMH. Section 3 describes the methodology employed in the paper and explains the construction of the data set. Section 4 presents in details our empirical results. The final section provides summary and conclusions.

Literature review

In the EMH one of the important and crucial dogmas is the idea about the information efficiency of the markets. It assumed that the market prices quickly reflect all available information. According to the information efficiency the market prices are unpredictable and follow a random walk while all information is reflected in the prices. The most common violation of the EMH is that of its weak form, namely that future prices of the financial assets cannot be estimated using the past values. This weak-form of EMH market inefficiency is more common for the developing markets and the SEE don’t make exception. In their article, Armeanu and Cioaca (2014) test the EMH in the case of Romania for 01.01.2002 -15.05.2014 using four methods, including GARCH model. They find out that the Romanian capital market is not weak-form efficient. Panagiotidis (2008) tests the weak form EMH for the Athens Stock Exchange after the introduction of the euro. Five statistical test and alternative models from the GARCH family are presented in order to examine the behavior of the General ASE Composite Index and the FTSE/ASE 20. The author rejects the random walk hypothesis and leads to the conclusion that the preferred model is TGARCH suggesting that leverage effects exist and the news impact is asymmetric. Aga and Kocaman (2011) test the weak form of efficiency for return index-20 in Istanbul Stock Exchange (ISE) for the period 1986-2005. They lead to the conclusion that there is a weak form of efficiency in ISE, which means that the market is weakly efficient if the current time cannot be explained with the past values. Guidi, Gupta and Maheshwari (2011) examine the validity of the weak form of EMH for central and eastern European (CEE) equity markets for the sample period from 1999 to 2009. They use in their study autocorrelation analysis, the run test and GARCH models. The results of the autocorrelation analysis indicate that the return of CEE indices does not follow random walk and particularly when the CEE joined the European Union, while applying the run test CEE markets improve their efficiency after they joined the CEE. The findings show that some of the CEE markets are weak-form inefficient. Borges (2010) study stock markets of France, Germany, UK, Greece, Portugal and Spain to check for the presence of random walk for the period from January 1993 to December 2007. Using both parametric and nonparametric tests, he finds evidence of random walk in all six countries for monthly return. Moreover, the hypothesis of random walk was rejected for Portugal and Greece for the daily return. Analyzing the existence of long memory in return series for nine indices from Central Eastern European (Romania, Hungary, Slovakia, Czech Republic, Ukraine) and Balkan emerging markets (Serbia, Bulgaria, Greece, Croatia) Pece, Ludusan and Mutu (2013) have found mixed results depending on the statistical methods that are used. But other of their findings shows that all indices, except Czech index, have a predictable behavior, so the investors can obtain abnormal profits, suggesting that these capital markets are not weak-form efficient. Dragota and Oprea (2014) investigate the Romanian stock market’s informational efficiency and find out that the predictability of returns suggest that the Romanian stock market has a low level of efficiency. Furthermore, the impact of new information is more intense before and after its release. Evidence of violation of the EMH can be found at Serbia’s capital market. In the study conducted by Miljković and Radović (2006) evidence that the Serbian stock market does not show efficiency even in the weak-form of EMH is presented. They find statistically significant levels of autocorrelation in returns with high kurtosis distribution, considerably different from the normal one.

Horobe and Lupu (2009) examine the degree of market integration from the standpoint of the rapidity embedded in the markets' reactions to the information revealed in the past, using a set of data that covers four years and a half and returns from markets that are members of the European Union, both developed – Austria, France, Germany and the United Kingdom, and emerging – the Czech Republic, Hungary, Poland, Romania and Russian Federation. The results indicate that the markets react quite quickly to the information included in the returns on the other markets, and that this flow of information takes place in both directions, from the developed markets to the emerging ones, and vice versa. At the same time, investors on emerging markets seem to take into account information from the other emerging markets in the region. Their research shows that many of examined markets maintain a long-term relation between them and the authors make assumptions that their degree of integration is higher than previously thought. Samitas, Kenourgios and Paltalidis (2011) study long-run relationships among five Balkan emerging stock markets (Turkey, Romania, Bulgaria, Croatia, and Serbia), the US and three developed European markets (UK, Germany and Greece) during the period 2000-2006. Results indicate that both domestic and external factors affect the Balkan stock markets, shaping their long-run equilibrium. Overall, they show evidence in favor of significant long-run relations between the Balkan emerging markets within the region and globally. The Syriopoulos and Roumpis (2009) researches show that the Balkan stock markets are seen to exhibit time-varying correlations as a peer group, although the correlations with the mature markets remain relatively modest. Sengonul and Degirmen (2010) investigate the impact of recent global financial crisis on the weak-form of efficiency of markets of the countries from 2004 enlargement of the European Union, Bulgaria and Romania on the one hand, and Turkey on the other hand. The results indicate that Bulgaria, Romania, Estonia, Lithuania, Malta and Slovenia demonstrate a weak-form of market inefficiency during both the pre-crisis and the post-crisis periods. The Czech Republic, Cyprus and Latvia clearly depart from weak-form of efficiency after the crisis. Among the studied countries, Hungary, Slovakia and Turkey perform better. Among three of them, Hungary appears the most efficient while Slovakia and Turkey follow her with slight departing from efficiency.

Similarity in which Balkan markets incorporate the market information can be found in the existence of market anomalies. Investigating calendar anomalies for five SEE stock markets (Bulgaria, Croatia, Greece, Romania and Turkey) during the period 2000-2008, Georgantopoulos, Kenourgios and Tsamis (2011) find evidence for the existence of three calendar effects (day of the week, turn of the month, time of the month) in both mean and volatility equations for Greece and Turkey, which is consistent to the findings of previous studies. On the other hand, the effects for the three emerging SEE markets are limited and exist only in volatility.

In order to assess the impact of the 2008 financial crisis on the interconnection among the SEE stock markets (Macedonian, Croatian, Slovenian, Serbian, and Bulgarian) Zdravkovski (2016) finds out no evidence of cointegration between studied markets during the pre- and post-crisis periods. However, during the 2008 financial crisis, the empirical findings support the existence of three cointegration vectors. This means that the recent global financial crisis and the subsequent euro crisis strengthened the connection between the investigated stock markets. Furthermore, the analysis reveals that during periods of financial turmoil, the Macedonian stock market is positively and actively influenced by the Croatian and Serbian markets. A significant implication of these results is that the integration between SEE stock markets tends to alter over time, particularly during stages of financial disturbances. The effect of 2008 financial crisis on the equity market returns of Bosnia-Herzegovina, Croatia and Serbia is studied by Ergun and Mahmutović (2014) by employing GARCH model to daily data spans from 2006 to 2012. Empirical result indicates that volatility of Serbian stock market is influenced by the volatility of Bosnian and

Croatian stock markets. There is one-way volatility transmission from Bosnian and Croatian stock markets to Serbian stock market. Additionally, all three-stock market's volatility is being influenced by its own shocks and information channels.

Analyzing the Bulgarian and Serbian capital markets with taking into account the 2008 crisis Simeonov (2015) point out that even similarities between two economies, their markets show different reaction to the effects of the crisis. Despite the normally highly volatile capital markets the Serbian investment activity is more vital and more optimistic, than the Bulgarian, which supports the real sector and the economy, as whole. While, the investors on the BSE-Sofia are expressively disposed to undervalue the economic activity, they have continued to behave markedly timorous since 2008. The last fact is a result partially of the naive optimism, spread by the end of 2007.

Studding the impact of 2008 financial crisis on the efficiency of the capital markets of Central and Eastern European (CEE) countries Tsenkov (2015) found differences in market reaction of two of studied markets in the comparison with the rest CEE markets. The Bulgarian and the Romanian indices showed disposition for faster and more sensitive reaction to negative market impulses, typical for the Crisis Period, in contrast to a moderate incorporation of the positive market impulses specific to the Pre-crisis Period. Incorporation of the market information by Bulgarian SOFIX during Crisis Period is so accelerated that when it becomes publicly available much of the content is already included in the values of SOFIX under the form of strongly followed market trend. This type of reaction is opposite to the behavior from other CEE indices which follows more sustainable market trends during the pre-crisis period and gives much lower significance of the new market information. This market behavior changes during the Crisis Period, showing an enhanced response only to the short-term market fluctuations. During the Post-crisis Period the Bulgarian and the Romanian indices are showing predisposition to the short-term market trends. This is opposite to the

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other CEE indices which tend to form and pursue longer-term market trends.

Methodology

In this paper, we test the information efficiency in eleven capital markets in the context of EMH. The data include daily closing prices of the indexes of the South-Eastern European countries over the period from 1st January 2005 to 4th November 2015. These closing prices have been taken from the Stock Exchanges' websites in the analyzed countries. In this study, daily returns (r_t) were calculated as following: $r_t = \log(P_t / P_{t-1})$, where P_t and P_{t-1} are the closing value of the market index at the current day and previous day, respectively. The whole period is divided into three sub-periods: pre-crisis, crisis and post-crisis. The separation of the sub-periods is done according to the highest and lowest value of the examined indices in the whole period. In order to estimate the informational efficiency, the models of the GARCH- family models (GARCH, EGARCH, TGARCH and PGARCH) have been applied and the best model has been chosen for each index.

Higher order GARCH models, denoted GARCH (*q*, *p*) can be estimated by choosing either *q* or *p* greater than 1 where *q* is the order of the autoregressive GARCH terms and *p* is the order of the moving average ARCH terms.

The representation of the **GARCH (*q, p*)** variance is:

$$\sigma_t^2 = \omega + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 \quad (1)$$

The EGARCH or Exponential GARCH model was proposed by Nelson (1991). The specification for the conditional variance is:

$$\log(\sigma_t^2) = \omega + \sum_{j=1}^{q} \beta_j \log(\sigma_{t-j}^2) + \sum_{i=1}^{p} \alpha_i \left| \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right| + \sum_{k=1}^{r} \gamma_k \frac{\varepsilon_{t-k}}{\sigma_{t-k}} \quad (2)$$

Note that the left-hand side is the log of the conditional variance. This implies that the leverage effect is exponential, rather than quadratic, and that forecasts of the conditional variance are guaranteed to be nonnegative. The presence of leverage effects can be tested by the hypothesis that $¥_i < 0$. The impact is asymmetric if $¥_i \neq 0$.

The Threshold GARCH (TGARCH) Model

TARCH or Threshold ARCH and Threshold GARCH were introduced independently by Zakoïan (1994) and Glosten, Jaganathan, and Runkle (1993). The generalized specification for the conditional variance is given by:

$$±_t^2 = µ + \sum_{j=1}^{q} \ _j ±_{t-j}^2 + \sum_{i=1}^{p} \sim_i £_{t-i}^2 + \sum_{k=1}^{r} ¥_k £_{t-k}^2 I_{t-k} \qquad (3)$$

where $I_t = 1$ if $£_t < 0$ and 0 otherwise.

In this model, good news, $£_{t-i} > 0$, and bad news $£_{t-i} < 0$, have differential effects on the conditional variance; good news has an impact of $\sim_i$, while bad news has an impact of $\sim_i + ¥_i$. If $¥_i > 0$, bad news increases volatility, and we say that there is a *leverage effect* for the i-th order. If $¥_i \neq 0$, the news impact is asymmetric.

The Power GARCH (PGARCH) Model

Taylor (1986) and Schwert (1989) introduced the standard deviation GARCH model, where the standard deviation is modeled rather than the variance. This model, along with several other models, is generalized in Ding et al. (1993) with the Power ARCH specification. In the Power ARCH model, the power parameter $¢$ of the standard deviation can be estimated rather than imposed, and the optional $¥$ parameters are added to capture asymmetry of up to order r:

$$\pm_t^{\text{¢}} = \mu + \sum_{j=1}^{q} {}_j\pm_{t-j}^{\text{¢}} + \sum_{i=1}^{p} \sim_i (|\pounds_{t-i}| - \text{¥}_i \pounds_{t-i})^{\text{¢}} \tag{4}$$

where $\text{¢} > 0, |\text{¥}_i| \leq 1$ for $i = 1,....,r, \text{¥}_i = 0$, for all $i > r$, and $r \leq p.$.

The symmetric model sets $\text{¥}_i = 0$ for all i . Note that if $\text{¢} = 2$ and $\text{¥}_i = 0$ for all i , the PARCH model is simply a standard GARCH specification. As in the previous models, the asymmetric effects are present if $\text{¥} \neq 0$.

Table 1. Analyzed indices, periods under examination and number of observations

Index/Period	Pre-crisis period/number of observations	Crisis period/number of observations	Post-crisis period/ number of observations
The Bulgarian index SOFIX	03.01.2005–15.10.2007/705	16.10.2007–24.02.2009/335	25.02.2009 – 04.11.2015/1653
The Banja Luka index BIRS	10.01.2005–16.04.2007/530	17.04.2007 – 02.08.2010/819	03.08.2010 – 04.11.2015/1311
The Sarajevo index BIFX	05.01.2005–17.04.2007/572	18.04.2007 – 14.12.2010/915	15.12.2010 – 04.11.2015/1221
The Greek index Athex Composite Share Price(ACSP)	03.01.2005 – 31.10.2007/709	01.11.2007 – 07.06.2010/643	08.06.2010 – 04.11.2015/1352
The Macedonian index MBI10	04.01.2005 – 31.08.2007/ 633	03.09.2007 – 10.03.2009/375	11.03.2009 – 04.11.2015/1632
The Romanian index BET	03.01.2005 – 24.07.2007/ 637	25.07.2007 – 25.02.2009/396	26.02.2009 – 04.11.2015/1684
The Serbian index BELEX15	04.10.2005 – 03.05.2007/391	04.05.2007– 11.03.2009/472	12.03.2009 – 04.11.2015/1679
The Croatian index CROBEX	03.01.2005 – 15.10.2007/727	16.10.2007 – 09.03.2009/344	10.03.2009 – 04.11.2015/1663
The Slovenian index SBI TOP	31.03.2006 – 31.08.2007/ 350	03.09.2007 – 23.12.2008/327	24.12.2008 – 04.11.2015/1718
The Turkish index BIST100	03.01.2005 – 15.10.2007/703	16.10.2007 – 20.11.2008/278	21.11.2008 – 04.11.2015/1746
The Montenegrin index MONEX	10.01.2005 – 07.05.2007/575	08.05.2007 – 04.12.2008/393	05.12.2008 – 04.11.2015/1707

Table 2. The best GARCH models of the GARCH family for each index

Indices	Period under examination – 01.01.2005г. – 04.11.2015г.	Pre-crisis period	Crisis period	Post-crisis period
BIRS	*TGARCH(2,2)- t*	*GARCH(2,1)-t*	*PGARCH(2,2)-t*	*TGARCH(2,1)-t*
BIFX	*GARCH(2,2)-t*	*GARCH(2,1)-t*	*GARCH(2,1)-t*	*EGARCH(2,2)-t*
SOFIX	*GARCH(2,2) -t*	*EGARCH(2,2)-t*	*PGARCH(2,2)-t*	*GARCH(1,1)-t*
CROBEX	*GARCH(2,2)-t*	*TGARCH(2,2)-t*	*TGARCH(2,1)-t*	*PGARCH(2,2)-t*
ACSP	*PARCH(2,1)-t*	*PGARCH(2,1)-t*	*TGARCH(2,2)-t*	*PGARCH(2,1)-t*
MBI10	*GARCH(2,2)-t*	*GARCH(2,1)-t*	*EGARCH(2,2)-t*	*GARCH(2,2)-t*
MONEX	*EGARCH(2,2)-t*	*TGARCH(2,2)-t*	*EGARCH(2,2)-t*	*EGARCH(2,1)-t*
BET	*EGARCH(2,1)-t*	*GARCH(2,2)-t*	*PGARCH(2,2)-t*	*GARCH(1,2)-t*
BELEX15	*GARCH(2,2)-t*	*GARCH(2,1)-t*	*PGARCH(2,2)-t*	*GARCH(2,2)-t*
SBI TOP	*GARCH(2,2)-t*	*GARCH(1,2)-t*	*PGARCH(2,1)-t*	*GARCH(2,1)-t*
BIST100	*TARCH(2,2)-t*	*EGARCH(1,1)-t*	*EGARCH(2,1)-t*	*GARCH(1,1)-t*

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Empirical data

The Whole Period; Table 3 shows the coefficient of persistence, leverage effect and power parameter for daily stock returns of the SEE indices for the whole analyzed period - 01.01.2004 – 04.11.2015. Here, we can make a note that coefficients of persistence take values in the range from 0.837173 (BIST100) to 1.011489 (ACSP). Also, we can separate the SEE indices into two groups according to the values of the coefficient of persistence. The first group contains indices MONEX and BIST100 with coefficients of persistence lower than 0.97. This leads us to the conclusion that the indices from the first group are with relatively high market efficiency. On the other hand, the second group includes BIRS, BIFX, SOFIX, CROBEX, ACSP, MBI10, BELEX15, SBI TOP and BET which coefficients of persistence are larger than 0.97. We should make important remark here that these indices above are with relatively low market efficiency.

Table 3. The value of the power parameter, coefficient of persistence and leverage coefficient for the sample period

Indices	Coefficient of persistence	Leverage coefficient *(Prob.)*	Power parameter* *(Prob)*	ARCH(1)** *(Prob)*	ARCH(2)** *(Prob)*
BIRS	1.003158	-0.006457 *(0.0000)*	NA	0.248206 *(0.0000)*	-0.243656 *(0.0000)*
BIFX	1.000438	NA	NA		
SOFIX	0.999957	NA	1.547060 *(0.0002)*		
CROBEX	0.998951	NA	NA		
ACSP	1.011489	0.556827 *(0.0044)*	0.706169 *(0.0000)*	0.074464 *(0.0011)*	0.054461 *(0.0450)*
MBI10	1.002842	NA	NA		
MONEX	0.893132	0.047719 *(0.0109)*	NA		
BET	0.984285	-0.030569 *(0.0162)*	NA		
BELEX15	0.999269	NA	NA		
SBI TOP	0.996553	NA	NA		
BIST100	0.837173	0.176648 *(0.0000)*	NA	-0.021530 *(0.2265)*	0.087876 *(0.0002)*

* *Only for PGARCH*

*** Only for TGARCH and PGARCH with power parameter close to 1*

The absolute values of the leverage coefficient represented in Table 3 for observed SEE indices are in the range from 0.006457 (BIRS) to 0.556827 (ACSP). In the TGARCH (2, 2)-t model, the good news has an impact on the volatility of 0.066346 while the bad news has an impact of 0.242994 for BIST100, indicating that good news generate less volatility than bad news. In comparison, the results of TGARCH (2, 2)-t for BIRS represents that the negative information has an influence of (-0.001907) showing that bad news decreases the volatility during the whole period. Additionally, we should analyze the values of power parameter (in the case of estimating PGARCH (2, 1)-t). First, for the ACSP the value of this parameter is almost unity (0.706169) meaning that the PGARCH becomes TGARCH model. Second, for the ACSP bad news increases the volatility (the leverage effect is set at 0.556827). Significantly, the indices ACSP (0.556827) and BIRS100 (0.176648) are with large in size and positive leverage coefficients (above 0.15), that means that the new information entering the market causes great changes in the volatility during the whole period under examination. By contrast, the leverage effect for the BIRS, MONEX and BET is with relatively low absolute value (0.006457, 0.047719 and 0.030569 respectively). We hypothesize that news has a less impact on the volatility.

The overall picture for the whole period is that the registered information asymmetry attributes to separation of the SEE indices into two groups. The first group contains indices ACSP and BIST100 which leverage coefficients have high absolute values indicating that market information has large effect on the volatility. The members of the second group are BIRS, MONEX and BET, which leverage coefficients have low value resulting in weak reaction to the new information entering the market and the attenuation of the information asymmetry. Moreover, the findings above about the values of the coefficient of persistence and related informational efficiency reveal that the SEE indices can be divided into two groups. The first group includes indices MONEX and BIST1000 characterized with high market efficiency (the value of coefficient of persistence is lower than 0.97) and the second group - BIRS, BIFX, SOFIX, CROBEX, ACSP, MBI10, BELEX15, SBI TOP and BET with market inefficiency (the value of coefficient of persistence is above 0.97).

Table 4. The value of the power parameter, coefficient of persistence and leverage coefficient for the pre-crisis period

Indices	Coefficient of persistence	Leverage coefficient *(Prob.)*	Power parameter* *(Prob)*	ARCH(1)** *(Prob)*	ARCH(2)** *(Prob)*
BIRS	0.943382	NA	NA		
BIFX	0.972619	NA	NA		
SOFIX	0.998017	0.028470 *(0.0000)*	NA		
CROBEX	1.018506	-0.037352 *(0.0000)*	NA	0.191528 *(0.0000)*	-0.177695 *(0.0000)*
ACSP	0.832917	0.291342 *(0.0386)*	2.415072 *(0.0006)*		
MBI10	1.009636	NA	NA		
MONEX	1.112547	-0.306875 *(0.0000)*	NA	0.436982 *(0.0000)*	0.341566 *(0.0000)*
BET	0.995716	NA	NA		
BELEX15	1.011707	NA	NA		
SBI TOP	0.872944	NA	NA		
BIST100	0.845742	-0.160402 *(0.0002)*	NA		

** Only for PGARCH*

*** Only for TGARCH and PGARCH with power parameter close to 1*

Pre-Crisis Period; Table 4 presents the values of coefficient of persistence, leverage effect and power parameter of the SEE indices for the pre-crisis period. The coefficients of persistence is in the range from 0.832917 (ACSP) to 1.112547 (MONEX) for the pre-crisis period. We should make important remark here that the index ACSP has the lowest value of the coefficient of persistence which lead us to the conclusion that this index is the most efficient one of the group. On contrast, the coefficient of persistence for MONEX has the highest value (1.112547) register that this index is the most inefficient. With this in mind, the analyzed indices can be divided into two groups according to the values of the coefficient of persistence (below or above 0.97). Within the first group are indices BIRS, ACSP, SBI TOP and BIST100 which value of coefficient of persistence is less than 0.97 implies that shocks decay with time. The second group contains indices BIFX, SOFIX, CROBEX, MBI10, MONEX, BET and BELEX15 with a coefficient of persistence greater than 0.97 represents the change in the response of shocks to volatility persistence, implies that the response of volatility increases with time. To put it another way, the SEE indices from the first group are relatively high efficient while the rest - with relatively low market efficiency. Significantly, the coefficients of persistence of BIRS, BIFX, SOFIX, ACSP and SBI TOP decrease their values in the pre-crisis period in comparison to the whole period. On the other hand, we notice an increase in the value of the coefficient of persistence of CROBEX, MBI10, MONEX, BET, BELEX15 and BIST100 during the pre-crisis period than these values in the sample period.

The values of the leverage effect for the pre-crisis period summarized in Table 4 are between -0.037352 (CROBEX) and 0.291342 (ACSP). Also the leverage effect of CROBEX is statistically significant at 5 % level and has the lowest absolute value with negative sign. Having said that, the highest value of leverage effect is calculated for ACSP (0.291342) during the pre-crisis period. In addition to this, estimating PGARCH (2, 1)-t for ACSP reveal that the power parameter is set at 2.415072 (close to two) meaning that PGARCH is simply GARCH model with leverage effect. Similarly, ACSP has great positive leverage effect showing that the new positive information entering the market has a significant influence on the volatility. Another key thing to remember is that the leverage coefficient of BIST100 has relatively high value with negative sign (-0.160402) providing that the predominant positive market dynamics reduces the volatility of the index. However the index SOFIX is with positive leverage coefficient lower than 0.15 (0.028470) leading us to the conclusion that the good news increases the volatility. Notably, the results of estimating TGARCH (2, 2)-t for CROBEX and MONEX show that the bad news decreases volatility (the values of the leverage

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coefficient are negative). We should make two important remarks here. Firstly, we register a reduction in the absolute value of the leverage coefficient of ACSP and BIST100 in the pre-crisis period in comparison to the whole period under examination. Secondly, the leverage effect of MONEX raise its absolute value from 0.047719 to 0.306875 during the pre-crisis period than this value in the sample period.

Summarizing the results for the coefficients of persistence during the pre-crisis period we can make two separate groups. The first group contains indices BIRS, ACSP, SBI TOP and BIST100 that are with high market efficiency due to their values of coefficient of persistence (from 0.832917 to 0.943382). If we consider the relatively high leverage ratio for indices ACSP and BIST100, we can conclude that these markets are informational inefficient, following most closely the immediate market impulses. Respectively, within second group are relatively low efficient indices – BIFX, SOFIX, CROBEX, MBI10, MONEX, BET and BELEX15 which values of coefficient of persistence is higher than 0.97.

Crisis Period; All of the displayed coefficients of persistence accept values between 0.902652 (CROBEX) and 0.997534 (BELEX15). Here we have to make two important observations. First, the values of coefficient of persistence of SOFIX, CROBEX, MBI10, MONEX, BET and BELEX15 for the crisis period are lower than the values of the coefficient of persistence of these indices during the pre-crisis period. Second, only indices SOFIX and CROBEX increase their information efficiency resulting in stronger reaction to the negative news leading to accelerated insertion of the market information in the value of volatility from the indices during crisis period in comparison to the pre-crisis period. By contrast the indices BIRS, BIFX, ACSP, SBI TOP and BIST100 increase their coefficients of persistence from pre-crisis to crisis period. Otherwise we should make a note about the following fluctuation - from 0.845742 to 0.970520 for BIST100 - which is the largest increase in the coefficient of persistence for all CEE indices. This can be attributed to the reduction in its informational efficiency from pre-crisis to crisis period, inflicting a short-term following the crisis market trends. What else we can do is to divide the SEE indices into two groups according to their values of the coefficient of persistence. Within first group are indices SOFIX, CROBEX, ACSP and SBI TOP with values of the coefficient of persistence lower than 0.97 indicating comparatively high market efficiency. The second group contains indices BIRS, BIFX, MBI10, MONEX, BET, BELEX15 and BIST100 with relatively low market efficiency due to the values of coefficient of persistence which are above 0.97 (from 0.970414 to 0.997534).

Table 5. The value of the power parameter, coefficient of persistence and leverage coefficient for the crisis period

Indices	Coefficient of persistence	Leverage coefficient *(Prob.)*	Power parameter* *(Prob)*	ARCH(1)** *(Prob)*	ARCH(2)** *(Prob)*
BIRS	0.994194	0.015974 *(0.0035)*	0.839295 *(0.0001)*	0.307103 *(0.0000)*	-0.314512 *(0.0000)*
BIFX	0.993213	NA	NA		
SOFIX	0.958897	0.309203 *(0.0293)*	0.779277 *(0.0150)*	0.265117 *(0.0035)*	-0.205233 *(0.0083)*
CROBEX	0.902652	0.160768 *(0.0031)*	NA	0.256644 *(0.0887)*	-0.256068 *(0.0582)*
ACSP	0.904329	0.106011 *(0.0009)*	NA	-0.072482 *(0.0488)*	0.096806 *(0.0146)*
MBI10	0.970414	-0.133168 *(0.0005)*	NA		
MONEX	0.974544	-0.075120 *(0.0000)*	NA		
BET	0.975037	0.122239 *(0.0017)*	1.306116 *(0.0000)*	0.366498 *(0.0000)*	-0.397543 *(0.0000)*
BELEX15	0.997534	0.078261 *(0.0190)*	0.880046 *(0.0065)*	0.469295 *(0.0000)*	-0.417239 *(0.0000)*
SBI TOP	0.968845	0.439148 *(0.0155)*	0.848168 *(0.0012)*	0.304371 *(0.0016)*	-0.191868 *(0.0530)*
BIST100	0.970520	-0.170078 *(0.0000)*	NA		

** Only for PGARCH*

*** Only for TGARCH and PGARCH with power parameter close to 1*

For the crisis period the absolute values of leverage coefficient are in the range between 0.015974 (BIRS) and 0.439148 (SBI TOP). Moreover the indices SOFIX, CROBEX and BIST100 increase their values of leverage coefficient from pre-crisis to crisis period. Here we

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can make a clarification that the leverage effects of the index SOFIX remain positive and statistically significant in the crisis period leading to the conclusion that negative crisis information has larger impact on the volatility in comparison to the positive information. On the other hand the leverage coefficients of the indices ACSP (from 0.291342 to 0.106011) and MONEX (from -0.306875 to -0.075120) decrease their absolute values from pre-crisis to crisis period resulting in weak response to the negative crisis impulses for these indices. The results from calculating PGARCH (2, 2)-t for BIRS, SOFIX, BET, BELEX15 and PGARCH (2, 1)-t for SBI TOP, respectively show that the power parameter is almost unity indicating that PGARCH model become a TGARCH model. Provided that the values of leverage coefficient are positive and statistically significant for these indices above, we can conclude that bad news increases volatility and there is a leverage effect. What's more, the negative information has a larger impact on the volatility than the positive information during the crisis period.

The overall picture for the crisis period is that five of the examined indices - BIRS, BIFX, ACSP, SBI TOP and BIST100 increase their values of coefficient of persistence from pre-crisis to crisis period. This observation lead us to the conclusion that these indices follow short-term crisis trends. Not to mention, that these five indices are with poor market efficiency during the crisis period. Further the indices SOFIX, CROBEX, MBI10, MONEX, BET and BELEX15 improve their market efficiency in the crisis period, conducting to a faster and stronger response to the negative crisis information in the crisis period in comparison to the reaction to the positive news during the pre-crisis period. However we should note that the indices SOFIX, ACSP, MBI10, MONEX, BET, BELEX15 and SBI TOP are with poor market efficiency during the crisis period. If we take into account that the leverage effect of SOFIX and CROBEX increases their values from pre-crisis to crisis period, we can summarize that these markets are highly dependent on short-term market trends, leading to more negative cyclical market impulses resulting in a large increase in market volatility.

Table 6. The value of the power parameter, coefficient of persistence and leverage coefficient for the post-crisis period

Indices	**Coefficient of persistence**	**Leverage coefficient *(Prob.)***	**Power parameter* *(Prob)***	**ARCH(1)** *(Prob)***	**ARCH(2) ** *(Prob)***
BIRS	1.049429	-0.076897 *(0.0378*)	NA	0.188313 *(0.0587)*	-0.122109 *(0.1351)*
BIFX	0.678517	0.019720 *(0.0113)*	NA		
SOFIX	0.946435	NA	NA		
CROB EX	1.004865	0.280859 *(0.0088)*	1.494922 *(0.0000)*	0.081093 *(0.0000)*	0.042340 *(0.0193)*
ACSP	1.052827	0.267348 *(0.0400)*	0.254571 *(0.0000)*	0.157484 *(0.0000)*	0.117415 *(0.0000)*
MBI10	0.995277	NA	NA		
MONE X	0.975875	0.034141 *(0.0456)*	NA		
BET	0.977684	NA	NA		
BELEX 15	0.999122	NA	NA		
SBI TOP	0.958086	NA	NA		
BIST10 0	0.962880	NA	NA		

** Only for PGARCH*

*** Only for TGARCH and PGARCH with power parameter close to 1*

Post-Crisis Period; The values of the coefficient of persistence for SEE indices shown in Table 6 are in range from 0.678517 (BIFX) to 1.052827 (ACSP). We should make important remark here that this low value of coefficient of persistence for BIFX (0.678517) can be explained with relatively low trading volume on Sarajevo illiquid market. Likewise, the coefficients of persistence of seven of the eleven SEE indices – BIRS, CROBEX, ACSP, MBI10, MONEX, BET and BELEX15 increase their values from crisis to post-crisis period. However, the indices with the lowest values of the coefficient of persistence are BIFX (0.678517) and SOFIX (0.946435). By contrast, the BIRS (1.049429) and ACSP (1.052827) have the highest coefficients of persistence in the post-crisis period. Here we also need to make an important note that the highest fluctuation is registered of the coefficient of persistence of BIFX – from 0.993213 to 0.678517 (from crisis to post-crisis period). This can be

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explained with the post-crisis recovery of the market leading to an improvement in its information efficiency. Otherwise, again two groups of SEE indices can be created due to the values of the coefficient of persistence in the post-crisis period. The first group contains the indices BIFX, SOFIX, SBI TOP and BIST100 with coefficients of persistence lower than 0.97. The indices of this group improve their market efficiency and during the post-crisis period are with higher information efficiency. Moving to the second group with indices BIRS, CROBEX, ACSP, MBI10, MONEX, BET and BELEX15 characterized with a poorer market efficiency. In the post-crisis period featured with positive market impulses, these market indices above strengthen the positive trends, leading to the most significant limitation of the volatility of all examined indices.

The absolute values of the leverage coefficient for the post-crisis period presented in Table 6 are between 0.019720 (BIFX) and 0.280859 (CROBEX). When it comes to Sarajevo, Bosnia and Herzegovina, the leverage coefficient of BIFX is with the lowest absolute value and with positive sign. Notably, estimating TGARCH (2, 1)-t for BIRS we find that good news (0.066204) generate more volatility than bad news (-0.010693) and also negative information decrease volatility in the post-crisis period. Due to the power coefficients of the indices CROBEX (1.494922) and ACSP (0.254571) which are almost unity, the PGARCH model become TGARCH. We assume that the positive information has less impact on the volatility than the negative information for CROBEX and ACSP. Also, bad news increase volatility and there is a leverage effect in the case of CROBEX and ACSP during the post-crisis period. However, we can separate SEE indices into two groups. Within the first group is only index MONEX which decrease the absolute value of its leverage coefficient from crisis to post crisis period (from 0.075120 to 0.034141). The second group contains indices BIRS, CROBEX and ACSP with a higher value of the leverage coefficient during the post-crisis period than in the crisis period.

Summarizing the results above for the post-crisis period, we can conclude that the indices do not improve their market efficiency. In the group of relatively low efficient markets are Croatia and Greece because of the high values of the coefficient of persistence and leverage ratio. With this in mind, in a direct comparison between pre- and post-crisis period we can figure out that there is a little improvement of market efficiency of the SEE indices. For instance, in the pre-crisis period the values of the coefficient of persistence are in the range from 0.832917 to 1.112547 while in the post-crisis period the values are between 0.678517 and 1.052827. Tables 4 to 6 shows the data for the dynamics of the coefficient of persistence for each of the examined indices. Indices BIRS, BIFX, ACSP, SBI TOP and BIST100 worsen their information efficiency from pre-crisis to crisis period. The type of market reaction for increased informational efficiency shown by the indices SOFIX, CROBEX, MBI10, MONEX, BET and BELEX15 is opposite, resulting in much stronger respond to negative crisis information during the crisis period. Here, we can add that the values of the returns of these indices incorporate in advance the negative market information during crisis period in comparison to pre-crisis period. In other words, the reaction on the market information in crisis period is so accelerated that when it becomes publicly available at the moment t most of the content is already included in the values of SOFIX, CROBEX, MBI10, MONEX, BET and BELEX15 under the form of followed strong market trends.

We can separate the analyzed SEE indices into two groups according to their reaction to the information entering the market using the values of the coefficient of persistence and relevant information efficiency. The first group includes SOFIX, CROBEX, MBI10, MONEX, BET BELEX15 and the second one – BIRS, BIFX, ACSP, SBI TOP and BIST100. All this leads us to the conclusion that indices within first group react faster and stronger to negative information during the crisis period in contrast to the moderate reaction to the positive news during the pre-crisis period. Furthermore, the second group of SEE indices has a contrary type of behavior expressed in following a stable market trends during the pre-crisis period and give significantly less importance of new information to the market than following the longer-term trends. In the post-crisis period the indices CROBEX, MBI10, MONEX, BET and BELEX15 increase their values of coefficient of persistence in comparison of their values in the crisis period. Here we also need to make the important note that these five indices- CROBEX, MBI10, MONEX, BET and BELEX15 return in a limited degree to moderate and short-term following of market trends, unlike the other SEE indices that are inclined to following of longer-term market trends.

Analysis of the data for the leverage coefficients presented in Tables 4 to 6 leads to the following conclusions:

The indices MONEX and ACSP decrease their absolute values of leverage coefficient during crisis period in comparison to those values in the pre-crisis period. These results show that information asymmetry for pre-crisis period has less influence on volatility than during the crisis period. Provided that during the crisis period with negative information impulses these two indices display a weak response to market information and a small increase in volatility. As well as indices MONEX and ACSP strongly follow market tendency during the pre-crisis period, characterized with growing market trend, resulting to a strong reaction to the positive market information and a greater decrease in the volatility.

We also should note that for the indices SOFIX, CROBEX and BIST100 there is an increase in the absolute values of their leverage coefficients from pre-crisis to crisis period. So, we can define that information asymmetry for those indices assign a stronger reaction to negative market news, giving them a greater weight in the equation of volatility compared with pre-crisis period characterized with positive information impulses. In the case of BIRS, SOFIX, BET, BELEX15 and SBI TOP during the crisis period negative news have a greater weight, resulting in a large increase in the volatility.

According to the correction of the information asymmetry and dynamics of leverage coefficients submitted in Table 6 we can classify the estimated indices into two groups for the post-crisis period. The first group includes only the index MONEX with a reduction of the absolute value of the leverage coefficient from crisis period to post-crisis period. All things considered it seems reasonable to assume that during the post-crisis period the dynamics of market information has less impact on volatility than the crisis period. Here we also need to make the important note that the post-crisis mitigation of the informational asymmetry is similar to the situation of the information asymmetry for pre-crisis period in which the market information has less influence on volatility than during the crisis period.

Moving on to the other group of indices BIRS, CROBEX and ACSP which leverage coefficients increase their values from crisis to post-crisis period. These results point in the direction that the indices above recover faster leading to that positive market impulses generate the highest of all analyzed indices reduction in the volatility of returns on those markets.

5. Conclusion

The findings above leads us to the following conclusions:

- The indices BIRS, BIFX, SOFIX, CROBEX, ACSP, BELEX15, SBI TOP, MBI10 and BET (Banja Luka, Sarajevo, Bulgaria, Croatia, Greece, Serbia, Macedonia and Romania, respectively) are defined as market inefficient according to the EMH during the whole period.
- In the pre-crisis period only Banja Luka, Greece, Slovenia and Turkey are weak-form market efficient.
- From pre-crisis to crisis period the SEE indices BIRS (Banja Luka), BIFX (Sarajevo, Bosnia and Herzegovina), ACSP (Greece), SBI TOP (Slovenia) and BIST100 (Turkey) worsen their market efficiency in the terms of the weak form of the EMH.
- In comparison with the pre-crisis period, four of the examined indices – MBI10 (Macedonia), MONEX (Montenegro), BELEX15

(Serbia) and BET (Romania) are with higher market efficiency during the crisis period.

- Four of the SEE markets –Sarajevo, Bulgaria, Slovenia and Turkey improve their weak form of market efficiency in the post-crisis period of recovery.
- The group of indices with relatively high market efficiency during the post-crisis period is the largest one in comparison with the previous periods.
- For the post-crisis period Sarajevo (Bosnia and Herzegovina), Bulgaria, Slovenia and Turkey are determined with high market efficiency.
- Only Slovenian capital market keeps its place in the group of the weak-form efficient markets for all three periods.
- The Macedonian index MBI10 is with poor market efficiency whether for the pre-crisis, crisis or post-crisis period.
- All things considered, it seems reasonable to assume that SEE capital markets aren't homogeneous in the contest of EMH.

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